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A Laboratory Notebook of Elementary Zoology

BY

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PART I.—MORPHOLOGY.

INTRODUCTION.

The following course of elementary zoology has been designed in order to give the student a general idea of the principles of the science, rather than a comprehensive survey of the whole animal kingdom. In a short course of this nature it is impossible to study in detail examples of every group, and therefore those types have been selected with which it is most important that the student should become acquainted.

In order to derive full advantage from the course, the following elementary rules of laboratory procedure must be observed.

Use of Microscope.—Always see that the eye-piece and objectives are clean. Lenses can usually be cleaned by breathing on them and then wiping with a clean cloth, preferably of silk. If any balsam has got on to the objective, the attention of the demonstrator should be called to it.

When examining an object always use the low power first. When focussing with the high power use the fine adjustment only and be very careful to avoid touching the cover-glass with the objective.

Use the plane mirror with the low power and the concave with the high.

Microscopic Preparations.—Always clean slides and cover-glasses before use. When covering an object, hold the cover-glass by the edges in order to avoid leaving finger-marks on it. Lower it gently on to the drop of liquid to avoid the inclusion of air-bubbles. Be very careful not to use too much liquid for mounting objects, as in this case it will run on to the top of the cover-glass and obscure vision. If this happens make a new preparation.

Dissecting.—Whenever possible dissect under water, as this prevents delicate objects from drying up and becoming distorted; in addition the various organs are supported and seen to better advantage. Change the water whenever it becomes turbid.

When exposing vessels and nerves dissect along and not across them, and keep the tissues slightly stretched.

Keep your instruments sharp, and always clean and dry them after use.

Drawing.—Make your drawings in the spaces provided for them. Do not make rough drawings on other paper and later on transfer them into this book; above all only draw what you see, not what you imagine to be present, and do not make copies of diagrams from text-books. Always use a sharp pencil. Label every structure shown in your drawings and insert the scales to which they are made.

Permanent Microscopic Preparations.—The principal object of a permanent preparation is, firstly, to preserve the appearance of the living animal or tissue and, secondly, to render apparent structures which are not visible during life. The first of these objects is attained by fixation, the second by staining and clearing.

By fixation is meant the rapid coagulation of protoplasm to prevent the decomposition processes which normally follow immediately after death. The principle fixatives are solutions of mercuric chloride, with or without the addition of acetic acid; and alcohol, picric acid and chromic acid mixtures. Alcohol and formalin, although largely used for preserving animals, are of less value for the fixation of objects for the microscope, as they often cause distortion.

As a general rule, it is not possible to stain tissues until the fixative has been washed out of them. The principal stains are hæmatoxylin, carmine, and eosin, used either in aqueous or alcoholic solution.

After having been stained the object has to be rendered transparent and mounted in some medium which will permanently preserve its shape. The medium generally employed is Canada balsam, a resin which is dissolved in xylol or benzol. As water will not mix with xylol, it is necessary first to replace the water in the tissue by alcohol, this process being called dehydration. The change from water to alcohol must be made gradually and is effected by passing the tissue through graded strengths of alcohol from thirty per cent to absolute. The object is now rendered transparent by being placed in xylol, etc., or some essential oil, a process known as clearing. The object can then be mounted in Canada balsam, which gradually hardens as the xylol evaporates.

In the case of larger animals, it is impossible to make preparations in the above manner, and in order to study the microscopic structure of their tissues it is necessary to cut the latter into thin sections. For this purpose the tissue is embedded in paraffin wax. This is done by transferring it from xylol into melted wax and then solidifying the latter. The block of wax containing the tissue is cut into thin sections by an instrument called a microtome. The sections are fixed to slides, the wax dissolved out by xylol and this replaced by alcohol. Afterwards the sections may be stained and mounted in the manner described above.

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1. Draw a side view indicating the following parts : foot ; body ; tube and draw-tube ; stage ; sub-stage with diaphragm and mirror, one side plane, the other concave ; coarse and fine adjustments ; eye-piece ; low and high power objectives ; nose-piece.

2. Paper.—Tear off a small piece of paper and mount it for microscopical examination by placing it on a slide, adding a drop of water, and covering it with a cover-glass. This is called a "fresh preparation." Examine it under both low and high powers and draw what you see. The black circles which may be present in this and the following preparations are air-bubbles.

3. Hair.—Make a similar fresh preparation of hair from your head. Draw what you see under both powers.

4. Elodea.—Examine a leaf under both powers. Notice how the leaf is divided into separate compartments called "cells." Draw what you see. Notice the movement of the protoplasm which is best seen in the cells at the tip of the leaf.

5. Diatoms.—Examine a drop of water containing diatoms which are plants composed of one cell only. Draw examples of them under the high power.

6. Epithelium.—Scrape the inside of your cheek with the back of your nail and make a fresh preparation of the material obtained. Make drawings under the high power showing the epithelial cells with nuclei.

7. Blood.—Prick your finger and make a fresh preparation of blood in the following manner :—

Put a drop of 0·9 per cent NaCl solution on the slide and then a drop of blood next to it. With the aid of a pin make the two drops run together and then put on a cover-glass. Draw : circular red cells ; irregularly shaped white cells.

8. External Features.—Draw a side view of a toad, natural size, showing: head; trunk; fore-limbs; hind-limbs; mouth; nostril or anterior nares; eye; tympanic membrane; sacral prominence; cloacal aperture. Indicate the position of the lymph heart.

9. External Features.—(*a*) Draw the right hand (*manus*), showing: digits 2–5 (first, corresponding to thumb, is absent). (*b*) Draw the right foot (*pes*), showing: digits 1–5; web.

10. Mouth.—Open the mouth widely and pull forward the tongue. Pass one bristle through a nostril into the mouth and another bristle through the punctured tympanic membrane, down the Eustachian tube. Make a drawing of the buccal cavity to show the following: groove in upper jaw, into which lower jaw fits; posterior nares; eye-balls; vomer and parasphenoid bones; openings of Eustachian tubes; commencement of œsophagus; glottis; tongue.

11. Muscular System.—Pin the frog on its back and remove the skin from the ventral surface. Make a drawing to show: rectus abdominis; pectoralis; obliquus externus; submandibular.

12. Muscular System.—Skin one of the hind-limbs and make a drawing of the ventral surface showing in the thigh: vastus internus; adductor longus; sartorius; adductor magnus; rectus internus major; rectus internus minor; in the shank: gastrocnemius and tendo Achillis; tibialis posticus; tibialis anticus.

13. Muscular System.—Draw a dorsal view of the same limb showing, in the thigh: rectus anticus femoris; vastus externus; biceps; semimembranosus; rectus internus minor; in the shank: gastrocnemius; peroneus; tibialis anticus

14. Muscle-Nerve Preparation.—Lay the toad on its belly and expose the sciatic nerve. Cut out the piece of backbone where the nerve arises and dissect out the nerve from its origin to the gastrocnemius muscle. Cut through the tendo Achillis, free the gastrocnemius and cut through the leg bones below and above the knee. Then pick up the " muscle-nerve preparation " by the bones and remove it from the remainder of the body. Make a drawing of it.

15. General Viscera.—Pin out the toad on its back and cut through the body-wall parallel to the anterior abdominal vein, continuing the cut forward through the pectoral girdle. Tie two ligatures round this vein near its entrance into the liver and cut between them. Pin out the flaps to right and left. Insert a blowpipe through the glottis and inflate the lungs. Make a drawing to show: heart; lungs; liver and gall-bladder; stomach; small intestine; rectum; mesentery; pancreas; hepato-pancreatic duct; spleen; kidneys; genital organs; fat bodies; bladder.

16. Urinogenital System.—Remove the alimentary canal by cutting through œsophagus, mesentery, and rectum. Make drawings to show: kidneys; ureters; fat bodies; supra-renal bodies; cloaca; bladder; and, in male: testes; vasa efferentia; vesiculæ seminales; in female: ovaries; oviducts; internal openings of oviducts.

17. Venous System.—Expose the heart by cutting through the pectoral girdle, open the pericardium and dissect the toad to show the following parts: ventricle; right and left auricles; sinus venosus; inferior vena cava; hepatic veins; superior venæ cavæ; external jugular, innominate, internal jugular, subscapular, subclavian, musculo-cutaneous, and brachial veins. Also pulmonary veins opening into left auricle. In your drawing indicate also the following nerves: glossopharyngeal (IX); vagus (X); hypoglossal (first spinal nerve); and brachial.

18. Arterial System.—Remove one superior vena cava and its branches and turn over the stomach, etc., to the right side of the toad. Dissect carefully along the arteries, beginning from the heart, and mark the following in your diagram : auricles ; ventricle ; truncus arteriosus ; carotid, systemic, and pulmo-cutaneous arches ; lingual artery ; carotid gland ; common carotid artery ; subclavian artery ; pulmonary and cutaneous arteries ; dorsal aorta ; cœliaco-mesenteric, spermatic or ovarian, renal and iliac arteries.

19. Portal Systems.—Dissect out the renal-portal and hepatic-portal systems. Draw: femoral, sciatic, renal-portal, dorso-lumbar, pelvic, anterior abdominal, hepatic-portal, and hepatic veins.

20. Heart.—Remove the heart from the body by cutting through the great vessels. Make enlarged drawings: (*a*) of the ventral side, showing: ventricle; auricles; truncus arteriosus; the three arterial arches; superior venæ cavæ; (*b*) of the dorsal side, showing in addition: sinus venosus; inferior vena cava; right and left pulmonary veins.

21. Nervous System.—Remove heart and viscera without injuring the aorta. Make a drawing to show: brachial plexus; brachial and spinal nerves; sympathetic chain and ganglia; sciatic plexus and nerves; also vertebræ, systemic arch, subclavian and vertebral arteries, dorsal aorta, iliac arteries.

22. Central Nervous System.—Remove roof of skull and neural arches. Make a drawing to show: olfactory lobes; cerebral hemispheres; thalamencephalon; optic lobes; cerebellum; fourth ventricle; medulla oblongata; spinal cord.

23. Central Nervous System.—Remove the brain from the skull and draw a ventral view showing: olfactory lobes; cerebral hemispheres; optic chiasma and nerves; infundibulum; pituitary body; crura cerebri; medulla oblongata; spinal cord.

24. Skeleton.—Examine the prepared skeleton on the demonstration table. Arrange the bones supplied to you in their natural positions viewed from the dorsal aspect. Make a drawing, naming the following parts: skull; vertebræ; urostyle; pectoral girdle; humerus; radio-ulna; carpal bones; metacarpals; phalanges; pelvic girdle; femur; tibio-fibula; astragulus; calcaneum; metatarsals; phalanges; calcar.

25. Skeleton.—Make enlarged drawings of a vertebra, both from the anterior and lateral aspects, showing : centrum ; neural arch ; neural canal ; neural spine ; transverse processes ; anterior and posterior zygapophyses

26. Skeleton.—Draw the pectoral girdle, showing : scapula ; suprascapula ; glenoid cavity ; clavicle ; coracoid ; epicoracoid ; sternum.

27. Skeleton.—Draw a lateral view of pelvic girdle, showing : ilium ; pubis ; ischium ; acetabulum.

28. Skeleton.—Draw an enlarged dorsal view of skull, showing: premaxillæ; maxillæ; nasals; anterior nares; sphenethmoid; frontoparietal; pro-otics; pterygoids; squamosals; quadratojugals; exoccipitals; foramen magnum.

29. Skeleton.—Make an enlarged ventral view of the skull, showing: premaxillæ; maxillæ; vomers; posterior nares; sphenethmoid; parasphenoid; palatines; pterygoids; quadratojugals; pro-otics; exoccipitals; occipital condyles.

30. Reproduction.—(*a*) Make a fresh preparation of a small piece of testis teased in a drop of 0·65 per cent salt solution and examine it under the high power. Draw examples of spermatozoa, showing head and tail; (*b*) examine a piece of ovary in the same way and draw unfertilized eggs on the same scale as the spermatozoa.

31. Development.—Draw eggs in different stages of development.

32. Development.—Look at the demonstration of living tadpoles.

33. Development.—Draw a specimen of a newly hatched tadpole, showing external gills and sucker.

34. Development.—Draw dorsal and ventral views of an older tadpole with internal gills, showing : mouth ; lips ; jaws ; nostrils ; eyes ; spout ; anus ; tail.

35. Development.—Draw dorsal and ventral views of a tadpole with rudiments of hind-limbs. Expose the gill-clefts and fore-limbs of this specimen by removing the operculum. Open the abdomen to show the heart, liver, and coiled intestine. Make drawings of your dissection.

36. Development.—Sketch a tadpole in the process of metamorphosis, showing: two pairs of limbs and shrinking tail.

37. Development.—Sketch a toad that has just completed its metamorphosis, showing the absence of tail.

38. Blood.—Make a fresh preparation of toad's blood in the same way as in number 7 using 0·65 per cent NaCl instead of 0·9. Draw the red and white blood corpuscles.

39. Lymph.—By means of a capillary tube remove some of the lymph from one of the lymph hearts. Make a fresh preparation of this lymph and draw examples of lymphocytes under the high power.

40. Stratified Epithelium.—Scrape the inside of your cheek with the handle of a scalpel and examine in 0·9 per cent NaCl solution. Make drawings of the epithelial cells showing the nuclei.

41. Pigment Cells.—Spread out a piece of toad's skin on a slide and examine it in 0·65 per cent NaCl solution under the high power. Draw the pigment cells.

42. Skin.—Examine the prepared section of toad's skin, stained with hæmatoxylin. Make drawings to show: horny and Malpighian layers of epidermis; dermis; pigment cells; saccular glands; connective tissue; blood-vessels.

43. Ciliated Epithelium.—Take a small piece of epithelium from the roof of the buccal cavity of a toad. Mount it in 0·65 per cent NaCl solution and draw the following, noting the ciliary movement: columnar epithelial cells; cilia; nuclei.

44. Connective Tissue.—Take a small piece of connective tissue from underneath a guinea-pig's skin and spread it out on a dry slide. After having covered with a dry cover-glass, irrigate with 0·9 per cent NaCl solution. Make a drawing under the high power to show the fibrillæ and connective tissue cells. Then irrigate with 1 per cent acetic and note solution of fibrillæ.

Examine the demonstration specimen.

45. Hyaline Cartilage.—Shave off a small piece of cartilage from the sternum or supra-scapula of a toad and mount it in 0·65 NaCl. Make a drawing to show: cartilage cells with nuclei; capsules; matrix.

Examine the demonstration specimen of a stained section.

46. Bone.—Examine and draw the prepared section of bone, showing: lamellæ; lacunæ; canaliculi; Haversian canals.

47. Small Intestine.—Examine the prepared section of the small intestine of a toad. Make a sketch of the whole section under the low power and then draw a small sector under the high power, showing: peritoneal epithelium; longitudinal muscle layer; circular muscle layer; connective tissue; blood vessels; lymph spaces; columnar epithelium.

48. Stomach.—Examine the section of a toad's stomach, noticing that the layers correspond with those of the intestine, and make two similar drawings to show: peritoneal epithelium; external connective tissue layer; thick circular muscle layer; connective tissue layer containing blood vessels; thin submucous muscle layer composed of longitudinal and circular muscle layers; gastric glands consisting of alveoli and ducts; columnar epithelium.

49. Unstriated Muscle.—Spread out a piece of toad's bladder on a dry slide, with its inner surface upwards. Make a drawing to show: unstriated muscle fibres with nuclei; epithelial cells.

Examine the demonstration specimen.

50. Striated Muscle.—Examine a small piece of muscle from the leg of a beetle.

51. Striated Muscle.—Tease a fragment of toad's muscle in 0·65 per cent NaCl and examine it. Draw: muscle sheath; muscle fibre; light and dark bands.

Examine the demonstration specimen showing nuclei.

52. Nerve.—Take a small piece of nerve from a toad, tease out one end in 0·65 per cent NaCl, mount and examine under both powers. Draw: nerve fibres; neurilemma; fatty sheath with nodes of Ranvier; axon.

53. Nerve.—Examine a transverse section of the sciatic nerve of a toad. Show in your drawing: perineurium, surrounding bundles of nerve fibres; neurilemma; fatty sheath; axon.

54. Nerve.—Examine the demonstration specimens of the following:—

(*a*) Nerve cell, showing nucleus; commencement of axon; basis of dendrites.
(*b*) Dendrites of a nerve cell of the brain.
(*c*) End-plate of an axon on a muscle fibre.

55. Living Animal.—Make a drawing to show: ectoplasm; endoplasm; nucleus; food particles and food vacuoles; contractile vacuole; pseudopodia. Afterwards draw outlines of one individual at short intervals to show the changes in form. Determine the rate of contraction of the contractile vacuole.

56. Stained Specimen.—Examine and draw the prepared slide.

57. Living Animal.—Make a fresh preparation of the fæces of a dysenteric patient, using only one drop and taking care not to let the material run from under the cover-glass. Make a drawing to show : ectoplasm ; endoplasm ; blunt pseudopodia ; nuclei ; also in E. histolytica ingested blood corpuscles.

N.B.—When you have finished do not clean your slide, but place it in the receptacle provided for this purpose.

58. Entamoeba coli.—Examine and draw the following demonstrations of stained specimens showing :—

(*a*) Amœbæ from the human intestine.

(*b*) Cyst with 8 nuclei.

59. Entamoeba histolytica.—Examine and draw the following demonstrations :—

(*a*) Amoeba from the intestine of a dysenteric patient with ingested red blood corpuscles.

(*b*) Section of ulcerated intestinal wall showing amœbæ invading the tissues.

(*c*) Cyst with 4 nuclei.

60. Living Animal.—Put a drop of water containing living Paramœcia on a slide and then put a drop of dilute gum next to it. With a needle make the two drops flow into one, but do not mix them. Put on a cover-glass and examine under both powers. The gum will slacken the movement of the animals. Draw an example to show : ectoplasm ; endoplasm ; cuticle ; cilia ; oral groove ; gullet ; food-particles enclosed in food-vacuoles ; two contractile vacuoles ; excretory particles ; macro-nucleus.

61. Stained Animal.—Examine the demonstration specimen of a stained Paramœcium showing, in addition to the parts mentioned in paragraph 60, the macro-nucleus and micro-nucleus.

62. Stained Animal.—Examine the demonstration slide of conjugating individuals.

63. Feeding Experiment.—Make a fresh preparation of Paramœcium, first mixing a drop of Indian ink with the water. Watch the ingestion of ink particles.

64. Contractile Vacuoles.—Put a drop of water containing living Paramœcia on a slide, add a few fibres of cotton wool, and cover. Select a stationary individual and watch carefully the emptying and refilling of a contractile vacuole, noticing the radial channels. Count the number of times the vacuole empties each minute. Then irrigate with 2 per cent NaCl and again count the number of contractions per minute.

65. Living Animal.—Make a fresh preparation of the contents of a toad's rectum in 0·65 per cent NaCl ; the large Ciliates present are Opalina. Draw an individual to show ; ectoplasm ; endoplasm ; cuticle ; cilia.

66. Stained Animal.—Irrigate the above preparation with iodine solution and draw a specimen showing the many nuclei. Examine the demonstration specimen of stained individuals.

67. Living Animals.—Make a fresh preparation in 0·65 per cent NaCl of the contents of the vesiculæ seminales of an earthworm. Observe parasites among the developing spermatozoa, and make drawings of the various stages of development, showing: young trophozoites surrounded by tails of spermatozoa; adult trophozoite; cysts containing two associating individuals; cysts containing spore-cases; boat-shaped spore-case containing spores.

68. Stained Animals.—Examine and draw the demonstration specimens of: (*a*) trophozoite with nucleus; (*b*) associating individuals; (*c*) spore-case containing spores.

69. In Man.—Examine the demonstration specimens of the blood of a man suffering from malaria and make drawings of the following :—

(*a*) Trophozoite.

(*b*) Trophozoite dividing into merozoites.

(*c*) Gametocyte (crescent).

70. In Mosquito.—Draw a section of the stomach of an infected mosquito showing cysts.

71. Living Animal.—Carefully lift the Hydra on to a slide and examine it in water under the low power without a cover-glass. Then put on a cover-glass, supporting it on one side by a bit of paper in order to prevent it from crushing the Hydra, and examine under the high power. Draw : body ; tentacles ; mouth ; also, if present, buds ; testis ; ovary.

72. Living Animal.—Make a fresh preparation of the Hydra and examine with both powers. Make drawing to show : ectoderm cells ; nematocysts with cnidocils ; endoderm cells.

Add 5 per cent NaCl and observe the discharge of filaments from the nematocysts. Draw examples of isolated nematocysts.

73. Transverse Section.—Examine the stained preparation under the high power and make a drawing to show: body-wall and digestive cavity; ectoderm, consisting of musculo-epithelial cells with nuclei and vacuoles; interstitial cells; nematocysts, both developing and fully formed; mesoglea; endoderm, consisting of granular secretory cells and vacuolated nutritive cells, some of which contain food particles.

73a. Demonstrations.—

(*a*) Whole animal expanded.
(*b*) ,, ,, retracted and containing food.
(*c*) ,, ,, budding.
(*d*) Transverse section through testis.
(*e*) ,, ,, ,, ovary.

74. Corals.—Examine the demonstration specimen of a colonial Hydroid and then sketch examples of corals.

75. Terminal-spined Eggs.—Examine a fresh preparation of the urine of a man infected with Bilharzia hæmatobium. Draw the eggs, showing egg-capsule with terminal spine and contained miracidium.

76. Lateral-spined Eggs.—Examine a fresh preparation of the fæces of a man infected with Bilharzia mansoni. Draw the eggs, showing egg-capsule with lateral spine and contained miracidium.

77. Miracidium.—Irrigate one of the above preparations with water. Watch an egg for some minutes and observe the escape of the miracidium. Make drawings showing egg-capsule ; miracidium with cilia, terminal projection for boring into snail, head-glands, gut, germ-cells, transverse band of nerve-fibres.

78. Snails.—Examine and draw the shells of the snails into which the miracidia bore and in which they develop in Egypt. Bilharzia hæmatobium only develops in Bullinus and B. mansoni in Planorbis. Look at the demonstration of the living snails. In addition draw an example of the shell of a right-handed snail for comparison with the left-handed shell of Bullinus.

79. Sporocysts and Cercariæ.—Examine the fresh preparation from the liver of an infected snail. Draw a sporocyst, showing the contained embryos, and then draw the successive stages in the development of cercariæ, showing: two suckers; forked gut; forked tail.

80. Adults.—Examine the demonstration specimen, showing pairs of adult worms in the portal vein of man. Make a sketch of this.

81. Adults.—Examine and draw the prepared slide of the adult worm, showing: two suckers; œsophagus; forked intestine uniting posteriorly; and, in male, groove for reception of female, testes; in female, vitelline glands, ovary, uterus containing ova.

82. Bilharziasis.—Examine the demonstration specimen of the bladder of a man infected with Bilharzia hæmatobium and the rectum of a man infected with B. mansoni. Observe the changes in the tissues caused by the presence of the eggs.

83. Eggs.—Examine the preparation of fæces from a man infected with tapeworm. Draw an egg showing the egg-cases and the contained onchosphere with six hooks.

Draw the demonstration specimen of an egg under the oil-immersion.

84. Cysticercus.—Examine the demonstration specimen of the cysticercus stage of Tænia saginata found in the muscles of infected cattle. Draw a pro-scolex or bladder-worm: (*a*) with scolex invaginated: (*b*) with scolex evaginated, showing the four suckers.

In addition examine demonstration specimens of cysticerci of Tænia solium occurring in the muscles, heart, and tongue of infected pigs.

85. Adult.—Draw several segments from different parts of the body of the cattle tape-worm provided, showing: scolex; thin neck; small anterior proglottides; larger posterior proglottides; genital openings.

86. Scolex.—Draw demonstration specimens of stained and mounted scolices of: (*a*) Tænia saginata, with four suckers; (*b*) Tænia solium, with a circle of hooks in addition.

87. Proglottis.—Draw the demonstration specimen of a stained and mounted proglottis seen under the binocular, showing: excretory canals; nerve cords; branching uterus containing eggs; vitellarium; shell-gland; vagina; ovaries and testes (often difficult to see); genital opening; vas deferens; penis.

88. Mature Proglottis.—Draw the demonstration specimen, showing the branched uterus full of eggs.

89. Cœnurus.—Draw the demonstration specimen of a bladder-worm, with many scolices, from the mesentery of an infected sheep. Also examine the specimens of cœnurus in the brain of a sheep and in the thorax of a rabbit.

90. Echinococcus.—Examine and draw the demonstration specimen of mother- and daughter-cysts of Tænia echinococcus from the liver of man, showing the small scolices on the walls of the daughter-cysts. At the same time look at the specimen of dead and calcified cysts in the lung of a camel.

91. Echinococcus.—Draw the prepared stained slide of scolices from inside a cyst of Tænia echinococcus from man, showing the scolex with invaginated suckers and ring of hooks.

92. Egg.—Examine the preparation of fæces of a man infected with Ascaris lumbricoides. Draw an egg to show the mammilated egg-case surrounding a large unsegmented ovum with nucleus.

93. Male.—Draw a lateral view of the worm, natural size, showing: head, with three lips surrounding the mouth; excretory pore; recurved posterior extremity; anus; copulatory spicules.

94. Female.—Make a similar drawing to show: head, etc.; excretory pore; vulva; anus.

95. Viscera.—Open the worm by a longitudinal dorsal incision and make drawings to show: œsophagus; intestine; anus; lateral excretory canals; and, in male, testis, vas deferens, vesicula seminalis, ductus ejaculatorius, copulatory spicules with sacs; in female, ovaries, oviducts, uteri, vagina, vulva.

96. Transverse Section.—Make a general drawing under the low power, showing: cuticle; syncytial outer layer; muscle fibres: dorsal and ventral lines, each containing nerves; lateral lines containing excretory canals; body-cavity; ovary or testis; oviduct or vas deferens; uterus or vesicula seminalis; intestine.

97. Transverse Section.—Draw (*a*) a muscle and (*b*) a section of the ovary under the high power. Show, in the muscle fibre, the contractile and non-contractile substances, the latter containing the nucleus and provided with a long process directed towards the dorsal or ventral line. In the ovary show the central cord with immature ova attached to it and the thin wall.

98. Eggs.—Examine the preparation of fæces of a man suffering from ankylostomiasis. Draw eggs in various stages of development, noting the transparent egg-capsule containing segmenting ovum, in two-cell, four-cell, or eight-cell stage.

99. Larvæ.—Examine the fæces from an infected man, which have been mixed with charcoal and allowed to stand for a week. Draw examples of (*a*) Rhabditiform larvæ, with moulted skin and pharynx with two swellings; and (*b*) Strongyloid larvæ, with cylindrical pharynx and rudimentary genital organs.

N.B.—When you have finished do not clean the slide, but put it into the receptacle provided for this purpose. Be careful not to get any larvæ on to your skin, as they bore through very rapidly.

100. Larva.—Examine and draw the section of skin, showing the penetration of the larvæ.

101. Male.—Examine the prepared slide under the low power and make a drawing to show: buccal capsule; pharynx; intestine; testis; vesicula seminalis; ductus ejaculatorius; genital bursa. Draw the latter under the high power, showing the supporting ribs and copulatory spicules.

102. Female.—Draw the prepared slide, showing: buccal capsule; pharynx; intestine; ovary; uterus with contained ova.

103. Buccal Capsule.—Make a drawing under the high power, showing: two pairs of ventral teeth; pair of dorsal teeth; median dorsal pharyngeal projection.

104. Ankylostomiasis.—Draw the demonstration specimens, showing: (*a*) piece of human intestine with attached worms; (*b*) section of human intestinal epithelium showing adult attached by buccal capsule; (*c*) male and female copulating.

105. External Features.—Draw a lateral view showing: prostomium; peristomium; mouth; rings of chætæ; clitellum; apertures of oviduct and vas deferens; anus.

106. External Features.—Draw an enlarged ventral view of the anterior twenty-five segments of the worm, showing the structures mentioned in the preceding paragraph.

107. Chætæ.—Remove one or two chætæ from the posterior end of the worm and draw them under the microscope.

108. Viscera.—Pin the worm ventral surface downwards by two pins through the sides of segment 4. Stretch the body and pin down the posterior end. Open the body-wall from segment 35 to the anterior end by cutting with scissors slightly to one side of the mid-dorsal line, taking great care not to cut the dorsal blood-vessel. Pin out the body-wall on either side, arranging the pins to mark segments 8, 12, 16, 20, etc. Draw your dissection, showing: cœlom; septa; alimentary canal, consisting of buccal region, pharynx, œsophagus, gizzard, intestine with cæca in segment 26, chloragogen cells; supra-pharyngeal ganglia; dorsal blood-vessel; four pairs of pseudo-hearts (segments 10–13); two pairs of vesiculæ seminales (segments 10 and 11); one pair of spermiducal glands (segment 18); two pairs of spermathecæ with diverticula (segments 6 and 7).

109. Blood System.—Make a diagram of the lateral aspect of the blood system showing: dorsal vessel; pseudo-hearts; sub-intestinal vessel; sub-neural vessel; parietal, œsophageal and intestinal vessels.

110 Viscera (cont.).—Remove the alimentary canal from the pharynx backwards, being careful not to injure the structures beneath it. Draw: spermathecæ with diverticula; vesiculæ seminales; vasa deferentia; spermiducal glands; ovaries; oviduct; nerve cord with ganglia. Open a vesicula seminalis to show the contained testis.

111. Nephridium.—Dissect out a nephridium of Lumbricus and examine it under the low power. Make a drawing to show: nephrostome; glandular part; blood capillaries; muscular terminal part.

112. Spermatozoa.—Remove a vesicula seminalis from a freshly killed worm, tease the contents in a drop of 0·6 per cent salt solution on a slide. Cover and examine under the high power. Draw spermatozoa at different stages of development.

113. Ovary.—With the aid of a needle and scalpel, dissect out one of the ovaries. Add a drop of alcohol and eosin and examine under the low power. Make a drawing to show the ova in various stages of development.

114. Development.—Draw the demonstration specimen showing egg-cocoon, embryo and young stages.

115. Transverse Section.—Make a drawing under the low power of the whole section to show: body-wall, consisting of cuticle, epidermis with gland-cells, circular and longitudinal muscle layers; peritoneum; mesentery; cœlom; alimentary canal, with endoderm and muscle layers; chloragogen cells; ventral nerve-cord showing nerve-cells and nerve-fibres; dorsal, sub-intestinal and neural blood-vessels, also networks of vessels in the wall of alimentary canal and in the body-wall; micro-nephridia; chætæ, with muscle-bands in some sections.

116. External Features.—Draw a dorsal view of an adult with its wings pinned out, showing: head; thorax; abdomen; antennæ; eyes; pro-, meso-, and meta-thorax; two pairs of wings; terga of abdominal segments 1–7 and 10; anal cerci, attached to tergum of segment 10; and, in male, styles attached to sternum of segment 9.

117. External Features.—Draw an enlarged ventral view of the abdomen of a male showing: sterna of abdominal segments 1–9; spiracles; styles on segment 9; podical plates; tergum of segment 10; anal cerci; genital aperture, between segments 9 and 10; anus, between podical plates and segment 10.

118. External Features.—Draw an enlarged ventral view of the abdomen of a female, showing: sterna of abdominal segments 1–6; spiracles; divided boat-shaped sternum of segment 7; genital funnel (sterna of segments 8 and 9); genital aperture, below podical plates.

119. Head.—Draw an enlarged lateral view of the head and neck, showing: antenna; eye; fenestra; maxillary palp; labial palp; labrum; cervical sclerites.

120. Head.—Draw an enlarged front view of the head, showing: antennæ; eyes; fenestræ; epicranial sutures; labrum; maxillary and labial palps.

121. Leg.—Isolate and draw one of the legs, showing: coxa; trochanter; femur; tibia; tarsus; claws; pulvillus.

122. Mouth Parts.—With the aid of a needle remove the mouth parts separately and draw them, showing : (*a*) mandibles ; (*b*) first maxillæ and maxillary palps ; (*c*) second maxillæ, joined together to form labium, with labial palps.

Examine the demonstration specimen of the mouth parts.

123. Egg Case.—Draw an egg-case, showing the partitions separating the sixteen eggs.

124. Viscera.—Fix the cockroach, ventral surface downwards, by pins through the sides and carefully remove the terga. Make a drawing to show the dorsal heart, and alary muscles. Then unravel the alimentary canal and draw: œsophagus; crop; gizzard; cæca; midgut; Malpighian tubules; small intestine; colon; rectum; salivary glands and receptacle; cerebral ganglion; fat-body.

125. Salivary Glands.—Remove one of the salivary glands with its receptacle and ducts. Draw it under the low power.

126. Tracheæ.—Remove a piece of the fat-body, mount it in water, and draw it under the high power, showing: tracheæ; fat-cells, containing fat-globules; fragments of Malpighian tubules.

127. Nervous System.—Remove the alimentary canal, and dissect away the fat-body in order to expose the ventral nerve-cord. Make a drawing to show: cerebral ganglion; circum-œsophageal commissures; sub-œsophageal ganglion; three thoracic ganglia; six abdominal ganglia; ventral nerve-cord.

128. Male Reproductive System.—Carefully remove the terga of abdominal segments 4 to 6 and expose the testes which lie just beneath them. Then expose the rest of the system and make a drawing to show: testes; vasa deferentia; vesiculæ seminales; ductus ejaculatorius; conglobate gland; gonapophyses.

129. Female Reproductive System.—Remove the dorsal surface of the abdomen and cut away the alimentary canal. Clear away the fat-body in order to expose the reproductive organs and make a drawing to show: ovaries; oviducts; spermathecæ; colleterial glands; gonapophyses.

130. Adult.—Make an enlarged drawing of the fly seen from the dorsal aspect, showing: head, compound eyes, ocelli, antennæ; thorax, bearing one pair of wings, one pair of halteres and three pairs of legs; abdomen, with four segments.

131. Head.—Draw an enlarged view of the head seen from in front, showing: compound exes, touching one another in the male, separated in female; ocelli; lunula; antennæ; proboscis, with terminal pad and palps.

132. Tarsus.—Mount a tarsus and examine under the low power Draw: joints; claws; pads; hairs.

133. Egg.—Draw some eggs under the low power of the microscope.

134. Larva.—Examine in water under the low power and make a drawing to show shape of body, conical in front, broader behind; head, with two-jointed antennæ; buccal hooks; eleven body segments; anterior spiracles; creeping pads on segments 2–9; posterior spiracles; and inside the body, alimentary canal, heart, and two tracheal trunks.

135. Pupa.—Make a drawing of the pupal case to show segments and remains of larval spiracles. In some cases the opening through which the adult has emerged can be seen.

136 A. Stomoxys.—Examine and draw the demonstration specimen of the stable fly. Notice that the proboscis, composed of labium, maxillæ and mandibles, is adapted for sucking blood.

136 B. Glossina.—Examine and draw the demonstration specimen of a tsetse-fly, with long, piercing and blood-sucking proboscis.

137. Male.—Examine both the living specimen and the prepared slide; make a drawing to show: head; proboscis; maxillary palps; antennæ; eyes; thorax; wings, with veins and scales; halteres; legs; abdomen of eight segments; claspers; anus.

138. Female.—Make a drawing to show the difference in length of maxillary palps, shape of antennæ, and absence of claspers.

139. Egg.—Draw an egg as seen under the microscope, showing: egg-case; operculum; developing larva.

Examine and draw the demonstration of an egg-mass.

140. Larva.—Examine both the living specimen and prepared slide. Draw: head, with mandibles, brushes, maxillary palps, antennæ; thorax; abdomen, with eight segments; anus; respiratory siphon; inside the body, alimentary canal, heart, and two tracheal trunks.

141. Pupa.—Examine both the living specimen and prepared slide. Make a drawing to show: fused head and thorax, with respiratory trumpets; abdomen of nine segments, with paddles on segment 8. Also eyes, proboscis, wings and legs of adult, seen through the pupal skin

Examine the demonstration slide showing an adult emerging from its pupal case.

142. Adults.—Examine and draw the demonstration specimens. Notice the long maxillary palps in both sexes.

143. Development.—Examine and draw the demonstration specimens, noticing in which characters they differ from the corresponding stages of Culex.

144. Male.—Examine the slide and draw: head, with eyes, four-jointed antennæ and proboscis; prothorax, with expanded edges; mesothorax, bearing a short pair of vestigeal wings covering metathorax; three pairs of legs, with two-jointed tarsi; abdomen, showing seven segments and anal piece with anus; large curved copulatory spicule; spiracles.

145. Female.—Make a drawing of the ventral surface of the abdomen to show: two gonopods bordering genital aperture; organ of Berlese on fourth abdominal segment.

146. Egg.—Draw an enlarged view, showing: egg-case; operculum; contained embryo.

147. Larva.—Draw the abdomen from the ventral aspect, showing the absence of genitalia.

148. Male.—Examine the prepared slide of the common body-louse and draw: head, with eyes, five-jointed antennæ, sucking-tube; pro-, meso-, and meta-thorax, each bearing a pair of legs terminating in sharp claws; eight abdominal segments, with chitinous plates; two pairs of thoracic spiracles and six lateral abdominal spiracles; anus; copulatory apparatus ending in a large chitinous penis, often retracted.

149. Female.—Draw the posterior end of the abdomen, showing: bilobed posterior extremity, caused by pair of gonopods bordering the vagina; eggs, contained in abdomen.

150. Egg.—Draw the demonstration specimen, under the binocular, of eggs attached to a piece of cloth, showing : egg-case ; tuberculated operculum ; contained embryo.

151. Larva.—Draw the abdomen to show the absence of genitalia.

152. Adult.—Draw a lateral view under the low power showing: head with simple eyes, antennæ lying in their grooves, maxillæ, four-jointed maxillary palps, labial palps and piercing apparatus; pro-,meso- and meta-thorax, with their respective sternites to which are attached the legs; thoracic spiracles; abdomen with spiracles, pygidium and, inside the body, recurved chitinous hairs of proventriculus; and in male, claspers and coiled spring-like organ; in female, receptaculum seminis.

152 A. Mouthparts.—Examine the demonstration slide of the head of a flea showing: pair of pointed mandibles with saw-like edges; single epipharynx; pair of first maxillæ with palps; labium with pair of labial palps.

153. Egg.—Draw an example under the low power.

154. Larva.—Draw a lateral view indicating: head; thirteen body-segments with hairs.

155. Pupa.—Draw a pupal case.

157. Male.—Make a drawing of the ventral surface, showing: body; four pairs of legs, with terminal claws and vestigeal pulvillus on each; capitulum; hypostome; two cheliceræ; two palps; genital aperture; anus; spiracles outside bases of fourth pair of legs; apertures of coxal glands, between first and second pairs of legs.

158. Female.—Draw a ventral view to show the female genital aperture.

159. Egg.—Draw an egg under the low power of the microscope.

160. Larva.—Examine and draw the prepared slide, showing: body; three pairs of legs, each with a well-developed pulvillus and pair of claws; capitulum; hypostome; cheliceræ; palps; anus.

161. Nymph.—Draw a ventral view to show the four pairs of legs, pair of spiracles and absence of genital aperture.

162. External Features.— Draw a side view of the rabbit, showing: head; neck; trunk; tail; limbs; pinnæ; eyes, with eyelashes and three eyelids; anterior nares; vibrissæ or whiskers; mouth; cleft upper-lip; anus; mammæ in the female.

163. External Features.—Draw posterior views of male and female, showing: anus; perineal pouches, with openings of perineal glands; in male, penis, prepuce, scrotal sacs; in female, vulva, clitoris.

164. Abdominal Viscera.—Fix the rabbit to the dissecting board by a nail through each foot, stretching the limbs to their full extent. Skin the ventral surface and observe the mammary glands in the female. Open up the abdomen by removing the ventral body-wall and make a drawing to show : liver, attached to diaphragm by falciform ligament ; stomach, with cardiac and pyloric regions ; duodenum ; small intestine ; cœcum ; colon ; rectum ; bladder.

165. Abdominal Viscera (cont.).—Turn over the alimentary canal and liver to the animal's right side. Then make a drawing to show, in addition to the structures already named: œsophagus; gall-bladder; bile-duct; hepatic portal vein; mesentery; pancreas, with duct; vermiform appendix; spleen; left supra-renal body, kidney, and ureter; genitalia; dorsal aorta; cœliac, hepatic, lieno-gastric, anterior mesenteric, renal, genital, posterior mesenteric and lumbar arteries; inferior vena cava; renal and genital veins; vagus nerve on œsophagus; cœliac and anterior mesenteric ganglia, close to the anterior mesenteric artery; splanchnic nerve; sympathetic chain; lumbar nerves. (All these nerves are much better seen after washing with a little methylated spirit.)

166. Alimentary Canal.—Ligature the portal vein and cut through it on the side nearest the intestine. Then remove the alimentary canal from the œsophagus to the rectum, and, having unravelled it, spread it out on the dissecting board and make a drawing to show the relative lengths of the various parts.

167. Head.—Skin the head and draw a side view to show : masseter muscle ; facial nerve ; lacrymal, infra-orbital, submaxillary, and parotid glands ; external auditory meatus.

168. Buccal Cavity.—Open the mouth widely and cut through the muscles at the angles of the jaws and make a drawing to show : teeth (incisors 2/1, premolars 3/2, molars 3/3) ; hard and soft palates ; posterior nares ; tongue ; pharynx ; œsophagus ; glottis ; epiglottis ; openings of Eustachian tubes, seen after cutting open the soft palate.

169. Thoracic Viscera.—Remove the ventral wall of the thorax, taking great care not to injure the blood vessels. Open the pericardium and draw : heart and pericardium ; lungs in pleural cavities ; thymus; trachea ; bronchi ; œsophagus ; diaphragm ; phrenic and vagus nerves.

170. Venous System.—Dissect out the veins leading to the heart and draw : heart, with right and left auricles and ventricles ; right and left anterior venæ cavæ, each formed by union of subclavian, external jugular, internal jugular, mammary, and anterior intercostal veins ; azygos vein on right side only ; inferior vena cava receiving the hepatic, renal, genital, ilio-lumbar, external iliac or femoral, and internal iliac veins.

171. Arterial System.—Cut away the anterior venæ cavæ and expose the anterior arteries and dissect out the posterior end of the dorsal aorta. Make a drawing to show heart, with pulmonary artery leading out of right ventricle, and aortic arch leading out of left ventricle; innominate artery, dividing into right subclavian and right carotid; left carotid, left subclavian, intercostal, cœliac, anterior mesenteric, renal, genital, posterior mesenteric, lumbar, sacral, and common iliac arteries. Each carotid branches into internal and external carotid, and each subclavian into brachial, vertebral, and internal mammary arteries.

172. Heart.—Remove the heart from the body by cutting through the bases of the great veins and arteries, examine in water, and make drawings of the dorsal and ventral aspects, showing: right and left auricles, right and left ventricles; aorta; superior and inferior venæ cavæ; pulmonary artery and vein.

173. Heart.—Examine the demonstration specimen of a human heart cut open to show the interior. Note relative thickness of ventricular walls; spongy interior of ventricles; mitral valve, guarding opening between left auricle and ventricle; tricuspid valve, between right auricle and ventricle; chordæ tendinæ; papillary muscles; semilunar valves at commencement of aorta and pulmonary artery; fossa ovalis; coronary arteries and veins.

174. Neck.—Open the abdominal cavity of another rabbit and remove the alimentary canal, taking care not to injure the genital organs. Raise the sternum in order to stretch the diaphragm and notice the expanded lungs seen through it. Then make a cut in the diaphragm and observe the collapse of the lung on that side. Fix the rabbit on its back by nails through feet and ears. Skin the ventral surface of the neck, being careful not to cut the external jugular veins. Make a median incision, commencing between the rami of the mandible and extending backwards.

NOTE.—Sub-maxillary glands ; larynx ; trachea ; œsophagus ; internal jugular veins ; thyroid gland ; carotid artery dividing into internal and external branches ; posterior cornua of hyoid ; hypoglossal nerve. With your finger stretch the connective tissue beside the right carotid artery to see the following nerves : vagus, with ganglion ; depressor and superior laryngeal branches of vagus ; ramus descendens of hypoglossal ; cervical sympathetic, with ganglion ; inferior (recurrent) branch of vagus lying next the trachea, looping round the subclavian artery at its commencement. Make a drawing showing the above structures.

Before leaving make a small hole in the roof of the skull, in order to allow the formalin to reach the brain, taking care not to injure the latter.

175. Male Urino-genital System.—Remove the ventral part of the pelvic girdle. Then dissect out and draw the following: kidneys; ureters; bladder; scrotum; testes; epididymes; gubernacula; spermatic cords, containing spermatic arteries, veins and nerves; vasa deferentia; uterus masculinus; prostate; Cowper's glands; urethra; penis, with gland, prepuce, corpus spongiosum and corpora cavernosa (the two latter are best seen by sectioning the penis); rectum; rectal glands; perineal glands; anus.

176. Female Urino-genital System.—Remove the ventral part of the pelvic girdle, dissect out and draw the following: kidneys; ureters; bladder; ovaries, with Graafian follicles; Fallopian tubes, each with a fimbriated opening; uteri; vagina; vestibule: vulva; clitoris; rectum; rectal glands; perineal glands; anus.

177. Fœtus.—Draw a side view of a young fœtus, with its membranes and placenta, removed from the uterus of a pregnant female, showing: placenta, with villi; allantois, with blood-vessels; yolk-sac; amnion; fœtus. Cut away the membranes and draw a side view of the exposed fœtus, showing: head, with lobes of brain; olfactory, optic and auditory capsules; gill arches; rudiments of limbs; umbilical stalk; tail.

178. Brain.—Cut away the roof of the skull and remove the brain, after having severed the cranial nerves as far as possible from their origins. Slice off the posterior region of the right cerebral hemisphere and make a drawing of the dorsal surface to show: olfactory lobes; cerebral hemispheres, with sulci; lateral ventricle; corpus callosum; right optic thalamus; right corpora quadrigemina; pineal body; cerebellum; medulla oblongata: spinal cord; roots of cranial nerves I, IV, IX, X, XI.

179. Brain.—Draw a ventral view, showing. olfactory lobes; cerebral hemispheres; optic chiasma; pituitary body, with infundibulum; pons Varolii; cerebellum; medulla oblongata; spinal cord; roots of cranial nerves, I, II, III, V, VI, VII, VIII, IX, X, XI, XII.

180. Eye.—Make a longitudinal section of the eye passing through the optic nerve. Draw the following: fatty tissue; sclerotic; choroid; retina; optic nerve; cornea; iris; lens; lens capsule; suspensory ligament; ciliary processes; ciliary muscle; anterior chamber, containing aqueous humour; posterior chamber, containing vitreous humour.

181. Skeleton.—Examine the demonstration specimen of a mounted skeleton and then arrange the bones supplied to you in their proper positions. Make drawings of the following parts (*see* paras. 182–191).

182. Skull, Dorsal View.—Premaxillæ; maxillæ; nasals; frontals; parietals; interparietals, supraoccipital; squamosal, with zygomatic process; jugal; anterior nares; orbit.

183. Skull, Lateral View.—Nasal; premaxillæ, with two incisor teeth; maxilla, with three premolar and three molar teeth, and zygomatic process; jugal; frontal; lacrymal; alisphenoid; orbitosphenoid; squamosal, with zygomatic process; tympanic, with bulla and external auditory meatus; orbit; optic foramen; foramen for cranial nerves III, IV, V, VI.

184. Skull, Ventral View.—Premaxillæ, with incisor teeth; maxillæ, with premolar and molar teeth, palatine and zygomatic processes; palatines; posterior nares; pterygoids; basisphenoid; basioccipital; exoccipitals, with occipital condyles; supraoccipital; foramen magnum; tympanic bullæ; glenoid fossæ; jugals.

185. Mandibles.—Inner aspect of one ramus: symphysis; condyle; incisor, two premolar and three molar teeth.

186. Vertebræ.—(*a*) Front view of a cervical vertebra, showing: centrum; neural arch and spine; neural canal; anterior zygapophyses; transverse processes; vertebr-arterial canal; (*b*) side view of a thoracic vertebra, showing: neural spine; facet for tuberculum of rib on transverse process; facet for head of rib on centrum; anterior and posterior zygapophyses; epiphyses; intervertebral notch for exit of spinal nerve; (*c*) side view of a lumbar vertebra, showing: neural spine; metapophyses; posterior zygapophysis; anapophysis; transverse process; centrum; epiphyses; hypapophysis; intervertebral notch for exit of spinal nerve.

187. Rib.—Consisting of head, tubercle, and shaft.

188. Pectoral Girdle.—(*a*) Dorsal surface of scapula, showing: blade; spine; acromion; coracoid process; glenoid cavity. (*b*) Clavicle. (*c*) Sternum, showing: sternebræ and xiphisternum.

189. Pelvic Girdle.—Ventral view, showing: ilia; ischia; pubes, with symphysis; obturator foramina; acetabula.

190. Fore-Limb.—(*a*) Humerus: head for articulation with glenoid cavity; bicipital groove on anterior face, with greater tuberosity outside and lesser inside it; trochlea, with articular surfaces for ulna and radius; olecranon fossa. (*b*) Radius and ulna: proximal cavities for articulation with trochlea; distal surfaces for articulation with carpus; olecranon process of ulna. (*c*) Carpus and five digits: nine carpal bones; five metacarpals; phalanges, two in first and three in each of other digits.

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191. Hind-Limb.—(*a*) Femur: head for articulation with acetabulum; greater, lesser, and third trochanters; digital fossa; condyles. (*b*) Tibia and fibula, the former showing: two proximal surfaces articulating with the condyles; two distal surfaces articulating with the tarsus. (*c*) Tarsus and four digits; six tarsal bones; four metatarsals; three phalanges in each digit.

192.—Draw successive stages of cell division :—

(*a*) Resting stage, showing : cytoplasm ; nucleus ; chromatin ; nuclear membrane ; nucleolus ; centrosome.

(*b*) Early division stage, showing : dissolution of nuclear membrane ; formation of spindle between two daughter centrosomes ; spireme.

(*c*) Later division stage, showing : chromosomes arranged on spindle.

(*d*) Succeeding stage, showing : chromosomes divided and moving apart.

(*e*) Final stage, showing : formation of daughter nuclei, and division of cytoplasm.

193. Maturation.—Examine the prepared section of the uterus of Ascaris containing eggs. Draw eggs, showing: (*a*) formation of first polar body; (*b*) formation of second polar body.

194. Fertilization.—Examine a section from the same uterus. Draw examples of eggs, showing the union of male pronucleus (head of spermatozoon) with female pronucleus.

195. Segmentation.—Examine the series of slides of developing Ascaris eggs. Make drawings to show: two-cell, four-cell, and eight-cell stages. Note the mitotic division.

196. Spermatozoa.—Examine the demonstration of living spermatozoa of the sea-urchin.

197. Unfertilized Eggs.—Draw examples of the living unfertilized eggs of the sea-urchin.

198. Fertilization.—Examine the sea-urchin eggs to which a suspension of spermatozoa has been added. Notice the spermatozoa crowding round the eggs and the formation of a membrane around the fertilized eggs.

199. Segmentation.—Draw two-cell, four-cell, eight-cell, and morula stages in the development of the egg of a sea-urchin. Note the fertilization membrane.

200. Blastula.—Draw the blastula stage of a sea-urchin, showing: single layer of cells, thicker at one pole; cilia; blastocoele; mesenchyme cells.

201. Gastrula.—Draw the gastrula stage of a sea-urchin, showing: ectoderm; endoderm; mesenchyme; archenteron; blastopore; blastocoele.

202. Older Gastrula.—Make a drawing showing, in addition to the above: coelomic pouches.

203. Phylum Protozoa.—See Nos. 55–70.

204. Phylum Porifera.—Examine and draw a sponge.

205. Phylum Cœlenterata.—See Nos. 71–74.

206. Phylum Platyhelminthes.—See Nos. 75–91.

207. Phylum Nemathelminthes.—See Nos. 92–104.

208. Phylum Rotifera.

209. Phylum Molluscoida.

210. Phylum Echinodermata.—Examine and draw a sea-urchin.

211. Phylum Annelida.—See Nos. 108–115. Examine and draw a leech.

212. Phylum Arthropoda.

Class Crustacea. Examine and draw a ventral view of a crab.

213. *Class Myriapoda.* Examine and draw a centipede.

214. *Class Insecta.*
Order Aptera.
„ *Orthoptera.* See Nos. 116–129 and draw a side view of a locust.

215. *Order Nemoptera.* Examine and draw a dorsal view of a dragon-fly.

216. *Order Hemiptera.* See Nos. 144–151.

217. *Order Coleoptera.* Examine and draw the dorsal view of a beetle.

218. *Order Hymenoptera.* Draw examples of a bee and an ant. Examine the demonstration specimen of the life history of the bee.

219. *Order Diptera.* See Nos. 130–143.

220. *Order Aphaniptera.* See Nos. 152–155.

221. *Order Lepidoptera.* Examine and draw the egg, larva, pupa, and adult of a moth.

222. *Class Arachnida.* Examine and draw a dorsal view of a scorpion.

223. Examine and draw a dorsal view of a spider under the hand lens. In addition see Nos. 157–161.

224. Phylum Mollusca.

Class Lamellibranchiata. Draw a lateral view of a fresh-water mussel extended to show the foot and siphons.

225. *Class Gastropoda.* Draw a living snail to show the body of the animal extended. See also No. 78.

226. *Class Cephalopoda.* Draw a posterior view of a Sepia, showing head with eyes, surrounded by ten arms with suckers, position of mouth, siphon, lateral fins.

227. Phylum Chordata.

Subphylum Vertebrata.

Class Pisces. Draw a lateral view of a dogfish showing head with mouth, eyes, nostrils ; body with gill clefts, lateral line, and fins ; tail with fins.

228. *Class Amphibia.* See Nos. 8–37.

229. *Class Reptilia.*

Order Lacertilia. Draw a lizard to show head with mouth, nostrils and eyes ; neck ; trunk with four limbs ; tail. Notice the scales covering the whole body and position of anus.

230. *Order Ophidia.* Draw a snake to show head with mouth, nostrils and eyes ; and limbless body. Notice the scales and position of anus.

231. *Class Aves.* Draw a bird with and without wings extended.

232. *Class Mammalia.* Draw the ventral view of a bat with wings extended. In addition see Nos. 162–191.

PART II.—PHYSIOLOGY.

1. Food substances of animals exemplified by the composition of milk :—

(*a*) Under the microscope milk seen to be an emulsion of fat in a solution of the remaining constituents.

(*b*) By centrifuging the fat is separated as cream.

(*c*) Acetic acid added to the remaining liquid precipitates the protein (casein).

(*d*) The filtrate from (*c*) tested with Fehling's solution shows the presence of sugar (lactose).

2. An organism having both plant and animal modes of nutrition : Euglena.

3. Symbiosis between an animal and a plant: specimen of an Acacia leaf showing :—

(*a*) Hollow thorns in which symbiotic ants live ;

(*b*) Protein food-bodies at the tips of the leaflets ;

(*c*) Nectary for providing carbohydrate food.

In addition examine the specimen of an ant.

3a. Symbiosis between an animal and a plant : transverse section of a green Hydra, showing symbiotic algæ inside the endoderm cells.

4. Digestion of protein: action of pepsin. Cubes of coagulated egg albumen were placed on the previous evening in three test-tubes containing respectively:—

(*a*) Scrapings from the stomach wall of a rabbit in 0·5 per cent HCl;

(*b*) Ditto in distilled water;

(*c*) 0·5 per cent HCl alone.

The test-tubes were kept overnight in an incubator at 36°. Note the state of the cubes in each tube.

5. Digestion of protein: action of trypsin. Cubes of coagulated egg albumen were placed on the previous evening in two test-tubes containing respectively:—

(*a*) Trypsin in 0·2 per cent $NaHCO_3$ solution;

(*b*) Ditto boiled.

The test-tubes were kept overnight in an incubator at 36°. Note the state of the cubes in each tube.

6. Digestion of carbohydrate: action of the diastase in mammalian saliva.

(*a*) Saliva seen to have an alkaline reaction ;

(*b*) Saliva is added to a dilute starch solution coloured with iodine in a test-tube. Note the rapid disappearance of the blue colour.

7. Digestion of carbohydrate: action of invertase of mammalian intestine. A piece of the small intestine of a rabbit has been kept overnight at 36° in a solution of cane sugar. Fehling's test is now applied to the solution.

8. Emulsion of fat: action of bile. Olive oil is shaken up in test tubes (*a*) with water and (*b*) with bile from an ox. Note the relative permanence of the emulsions formed.

9. Absorption of fat: section through the intestinal wall of a frog after a meal of fat to show the re-formation of fat globules inside the cells of the intestinal epithelium.

10. Peristalsis. Observe the nature of the peristaltic movements of (*a*) an isolated piece of mammalian intestine and (*b*) the intestine of a transparent invertebrate seen under the microscope.

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11. Fat storage. Note the microscopic appearance of fat storage tissue from (*a*) a toad and (*b*) an insect larva.

12. Gills of (*a*) a fish and (*b*) a young tadpole.

13. Respiratory movements. Observe the nature of the respiratory movements of the following animals :—

(*a*) Fresh-water annelids ;
(*b*) Aquatic dipteran larva in its tube ;
(*c*) Mosquito larvæ ;
(*d*) Mosquito pupæ ;
(*e*) A tadpole with internal gills ;
(*f*) A frog.

14. Air sacs of a bird inflated to show their extent.

15. Absorption spectra of hæmoglobin and oxyhæmoglobin. Examine the spectra, noting in addition that when the tube of hæmoglobin is shaken up with air the oxyhæmoglobin absorption spectrum appears in it.

16. Vertebrate blood.

(*a*) Blood treated with a soluble sulphate to remove the calcium and then centrifuged to show the relative volumes of corpuscles and plasma.

(*b*) Clotted blood : note the clot and the serum.

(*c*) Plasmolysis.

17. Heart beat of a toad. Examine the beating of the heart of an anæsthetized toad, noting the order in which the chambers contract.

18. Circulation of the blood in the bladder of a toad. Watch the rapid rhythmic flow in the arteries, the slow flow in the capillaries and the rapid even flow in the veins.

19. Lymph hearts. Examine the beating lymph hearts of an anæsthetized toad.

20. Blood circulation of an arthropod. Examine the transparent animal under the microscope noticing the nature of the heart beat, the opening and closing of the valves, and the circulating blood.

21. **Flame cells** of a Bilharzia miracidium seen under the $^1/_{12}$ inch oil-immersion objective.

22. **Nephridial funnels** of an annelid. Notice the beating of the cilia on the nephrostome.

23. **Cœlomic fluid** of an earthworm under the microscope showing chloragogen cells both whole and disintegrated, and leucocytes.

24. **Uric acid** excreted by Argas.

25. Digestive enzyme. Sections through a mammalian pancreas at intervals after a meal. Note the gradual evacuation of the granules of secretion from the cells into the lumen of the gland.

26. Venom. Specimen of a scorpion to show the sting and the position of the poison gland.

27. Venom of a toad exuding from the poison glands.

28. **Wax** secreted by (*a*) a mealy bug and (*b*) a scale insect.

29. **Silk** forming the cocoon of a silk moth.

30. **Spider's web**.

31. Pigments for protective colouration : photographs showing the changes in the colour pattern of a flat-fish, according to the nature of the ground on which it is lying.

32. Pigments for warning colouration: specimen of a wasp and also of a dipteron which mimics the wasp.

33. Amœboid movement.

34. Action of cilia of the gill of a mussel seen under the microscope. Note the quick forward movement and slower backward movement of an individual cilium.

34 A. Effect of ciliary movement in the roof of a toad's mouth.

35. Ciliary locomotion: examine swimming Paramœcia under the binocular microscope, noting the spiral path.

36. Action of muscles in an animal with an exoskeleton, illustrated by the claw muscles of a crab.

37. Muscular contraction: stimulation of the isolated sartorius muscle of a toad with the galvanic forceps.

38. Stimulation of a motor nerve. In a muscle-nerve preparation (see Part I, No. 14) stimulation of the sciatic nerve with a galvanic forceps causes the gastrocnemius muscle to contract.

39. Functions of the various parts of the central nervous system. Demonstration of the reflexes which remain when the following parts of the central, nervous system of a toad are successively removed: (*a*) fore-brain, (*b*) cerebellum (*c*) spinal cord.

40. **Pain:** examine a section through a cornea to see the free nerve-endings at the surface.

41. **Pressure sense organ:** examine the section of a tactile corpuscle, noting the central receptive cells with which the sensory nerve-endings are in contact, and the protective envelope of connective tissue.

42. **Pressure sense organ:** watch the small fresh-water annelids carrying out their swaying respiratory movements and notice how this movement is instantaneously stopped by a light tap on the glass vessel.

43. Statocyst : the statocyst of a shrimp seen under the microscope shows the central concretion resting on hairs which are in contact with the sensory nerve-endings.

44. Semi-circular canals : demonstration of the action and structure of the semi-circular canals.

(*a*) Model of a semi-circular canal ;

(*b*) Dissection of the semi-circular canals of a fish and of the branches of the 8th cranial nerve coming from the ampullæ.

45. Stimulus of sound: a leg joint of an orthopteran insect seen under the low power to show the membrane of the ear.

46. Stimulus of light: the eye of an albino rabbit arranged to show the inverted image on the retina. When the curved surface of the cornea is changed to a flat surface, by placing a microscope slide in front of the eye and filling the space between slide and cornea with water, the image on the retina vanishes. The image is caused to reappear by placing a suitable lens in front of the microscope slide.

47. Positively phototactic animals.

48. Negatively phototactic animals.

49. Negatively geotactic flies.

50. Geotaxis changed in sense according to the external conditions in the case of Paramœcium.

51. Chemotaxis.

(*a*) Flagellates moving into regions of optimum concentration of dissolved oxygen.

(*b*) A collection of leucocytes seen inside the mouth of a capillary tube containing starch, which was introduced on the previous day beneath the skin of a toad.

52. **Thigmotaxis** of (*a*) spermatozoa and (*b*) ticks.

53. **Response to sight of moving objects** in the case of fish.

54. Hæmoglobin crystals. Note the different shapes of crystals from different species of animals.

55. Pricipitins. Four small test-tubes are half-filled with :—

(1) Ox serum ;

(2) Horse serum ;

(3) Ox serum ;

(4) Horse serum.

To (1) and (2) is added serum from a rabbit which has been previously inoculated with ox serum and to (3) and (4) serum from a rabbit which has been inoculated with horse serum. Observe the effects of these additions.

56. Regeneration in Hydra of parts of the body which had been cut off.

57. Regeneration of lizard's tail. Compare the specimen with a regenerated tail with the specimen which has its tail intact.

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